Book Reviews

Industrial Ecology: Towards Closing the Material Cycle

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This book has been developed out of a research project performed at the European Institute of Business Administration (INSEAD, Fontainebleau, France) for the European Commission, DG XII (Science Research and Development). This study had the title "Material Optimization in the Production of Major Finished Materials" and was written by the authors of the book together with PAOLO FRANKL, HOWARD LEE, NICHOLE WOLFGANG and PAUL W. WEAVER. ROBERT U. AYRES is a Professor of Management and the Environment Chair Sandoz and the director of CMER at INSEAD, LESLIE W. AYRES is a research associate at the same center.

The book starts with a lucid analysis of industrial production from an economic and environmental point of view. Contrary to what neo-conservative economic scientists say, it has been shown that resource depletion (especially of high-quality ores and oil) and environmental problems have to be taken seriously in the accounts of economic analysis. The primary section of the book consists of a thorough analysis of the "life cycles" of many metals, basic chemicals and the minerals which are used as raw materials for the production of such metals and basic chemicals:

- Alumina, aluminum and gallium
- Copper, cobalt, silver and arsenic
- Chromium sources, uses and losses
- Zinc and cadmium
- Sulfur and sulfuric acid
- Phosphorous, fluorine and gypsum
- Nitrogen-based chemicals
- The chlor-alkali family
- Electronic grade silicon for semiconductors
- Post-consumer packaging wastes
- Scrap tires
- Coal ash: Sources and possible uses

As can be seen from the list, waste materials which could and should be used as secondary raw materials are also included. There is a great deal of "Life Cycle Thinking" in this book or, better, it is actually the basis of the book. Since the classic LCA methodology is not easily applied to materials (except in the truncated form of "cradle-to-factory-gate" LCI), life cycle thinking together with substance flow analysis is certainly the preferred approach. The charm of the book lies in the intimate mixture of economic, ecological and technical thinking and knowledge, a rare and fruitful mixture.

There is a great amount of useful data in the text which is supplemented by numerous tables in the appendices. The interdependence of many processes, especially for the metals occurring simultaneously in the ores, has also been worked out. Furthermore, advice is provided in every chapter for political measures which are to be taken in order to save resources and reduce environmental burdens at their roots, i.e. during raw material extraction. It is shown that the greatest benefit of recycling in many instances is the reduction of virgin material production and the corresponding reduction in co-generated toxic byproducts, e.g. in the cases of arsenic and cadmium. The same connection holds with regard to waste, since "Every increment of raw material extracted from the environment is a future waste or pollutant, after a delay of weeks, months, or (in a few cases) years."

In the last chapter of the book, an outline of "industrial ecosystems" is presented with an emphasis on system integration. Practical experiences from companies with pioneering projects are provided and the example of the Danish town Kalundborg where industrial ecology including an electric power plant, several industries, the heating of homes and even a fish farm (!) have been connected into one system since the 1960's is discussed in detail. This and other examples show that the industrial ecology is not merely a theoretical concept, but can be used in the real world.

For the LCA-practitioners, there will be a large field of activities in finding out the best solutions for systems of varying complexity. In order to be prepared for this task, however, a much better data base will be required. As noted in Appendix B which deals with the data base, the European statistical data is very poor and in many cases US data had to be taken as a substitute. The global data collected by UN agencies also turned out to be of inadequate use for the purpose of this book.

Finally, I would like to help those potential readers who are not familiar with the units used in this work: MT means metric tons or Mg (not Megatons), kMT accordingly 1000 metric tons or Gg, MMT designates a million metric tons or Tg. This is still to be found within the international system of units (SI), although with somewhat strange symbols. British thermal units (1 BTU corresponds roughly to 1 kJ), however, should not be used at all and MMBTU for one million BTUs is simply illogical since one MegaBTU should read MBTU. To be fair, however, the symbols are explained in an extensive list of abbreviations. There are also comprehensive indexes and 15 pages of quotations where I only missed some well-known names like BACCINI, BRUNNER and SCHMIDT-BLEEK whose holders have suggested similar ideas, although the methods proposed may differ.

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